Action of weak alkali on jute

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The effect of various weak alkalies at very low concentration (0.25%) on jute fibre has been studied. It is observed that sodium carbonate in very dilute solution cleans the fibre surface more without any damage. Also, the treated fibres become more regular to cause reduced spinning end breakage rate, leading to higher yarn productivity.

Keywords: Fibre morphology, Jute fibre, Spinning end breakage rate

1 Introduction
The inherent drawback of jute yarn is its poor quality and higher irregularity which is due to the multicellular nature of the fibre. The number of individual cells varies widely from fibre to fibre and also along the length of the fibre. These individual cells are cemented with lignin and hemicellulose and form a composite fibre. When the jute fibres are treated with alkali, non-cellulosic materials (mostly hemicellulose) dissolve, making the fibres regular which give rise to a better quality yarn for use in diversified product. Macmillan et al. gave a detailed account of the action of various alkalies on jute fibre and the extent of weight loss in the process. However, their study dealt only with the effect of different alkalies (at various concentrations with a minimum of 0.5% on the weight of jute) and it was found that the more the dissolution of the non-cellulosic materials, the more was the strength loss in jute yarn. The effect of weak alkalies on yarn properties was not studied. In the present study, the effect of weak alkalies of very low concentration (0.25%) on yarn properties has been studied considering that the weight loss will be low with weak alkali and the strength of yarn will not be affected much but the inter-fibre friction or the regularity of the fibre may increase, which would result in better spinning of jute yarn.

2 Materials and Methods
2.1 Preparation of Sample
Raw jute fibres (TD₄ and W₄ quality) were treated with 0.25% sodium carbonate, calcium hydroxide, liquor ammonia and sodium sulphite separately, keeping the material-to-liquor ratio at 1:10, for different durations at room temperature (25-27°C).

2.2 Chemical Analysis
The alkali-treated fibres were extracted with water and the combined alkali and water extract was analyzed for the estimation of pectin and other carbohydrates such as hemicellulose using the colorimetric method. The pectin was estimated quantitatively by CARRBozole reaction while the hemicellulose by the method of Sarkar et al. and Roy. The holocellulose, obtained from the single treatment of sodium chlorite on jute fibre, was treated with sodium hydroxide solution (9.3% w/w) at room temperature. To the filtrate, absolute alcohol was added and the hemicellulose was precipitated, washed with alcohol, dried and finally determined gravimetrically.

2.3 SEM Studies
For SEM studies, the fibre samples were first coated with a thin layer of gold-palladium alloy using a sputter coater and then observed in the secondary mode at a beam voltage of around 5 kV (ref. 2).

2.4 Tensile Properties
The tensile strength of the untreated and alkali-treated jute fibres was measured using an Instron tensile tester at a test length of 2 cm, keeping the time of break at 20 ± 5 s.

Jute fibres (TD₄) were treated with 0.25% Na₂CO₃ (on the weight of the fibre). The chemical was applied on jute along with 3% oil in water emulsion at the batching stage. The processed sliv-
er was spun with 4/4 in. slip-draft flyer spinning frame to make jute yarn of 8 lb (276 tex) linear density.

3 Results and Discussion

3.1 SEM Studies

The scanning electron photomicrographs of untreated and treated jute fibres (Figs 1-6) show the change in the morphology of the fibre and hence give an idea of how the fibre surface is affected with dilute alkalis. The photomicrograph of a raw jute fibre in untreated condition (Fig. 1) does not give any clear idea about the fibre surface. The individual cells of the multicellular fibre are not clear and some untreated material (mostly pectinous) is deposited on the fibre surface. The scanning electron photomicrographs of the jute fibre treated with 0.25% sodium carbonate for 1 h and of the fibres treated with 0.25% calcium hydroxide, liquor ammonia and sodium sulphite for 10 min (Fig. 2) show that liquor ammonia and sodium sulphite have hardly any effect on the fibre surface whereas sodium carbonate and calcium hydroxide result into the cleaner surface of the fibres. The untreated material is removed more and more by sodium carbonate and calcium hydroxide as the duration of treatment is increased. Fig. 3 shows the scanning electron photomicrographs of the fibres treated with Na₂CO₃ and calcium hydroxide for 240 min and 20 min respectively. It is observed that the surface of the sodium carbonate-treated fibre is clean and that the polygonal nature of the fibre is prominent. The cleaning by calcium hydroxide is stronger than that by sodium carbonate but sometimes the individual cells are separated and also get damaged. Moreover, there is a chance of calcium hydroxide deposition on the fibre surface as is evident from Fig. 4 which shows the surface features of the fibre treated with calcium hydroxide for 50 min. and of that treated with sodium carbonate for 8 h. The calcium hydroxide-treated fibre shows clear deposition of calcium salts whereas the sodium carbonate-treated fibre shows more clear surface than that in Fig. 3. The structural features (some fibrils) are visible because of better cleaning operation. Liquor ammonia and sodium sulphite have negligible effect as compared to sodium carbonate and calcium hydroxide. Also, these two alkalis are hazardous and were, therefore, not used in longer duration treatments.

The important feature that the above photomicrographs reveal is that calcium hydroxide treatment causes some decernenting action on the fibre, leading to separation of individual cells and damage to the fibre, whereas the sodium carbonate treatment cleans the fibre surface only and there is no decernenting as done by calcium hydroxide (Fig. 3) or by strong alkali like 17.5% NaOH solution (Fig. 5). This is also revealed from the photomicrograph of the fibre treated with Na₂CO₃ for longer period (Fig. 6). Since there is no decernenting in the multicellular structure by the weak alkali like 0.25% sodium carbonate, the fineness of the fibre may not be affected but the cleaning process may make the fibre more regular. As a result, the spinnability of the fibre may improve.

3.2 Chemical Analysis

The chemical analysis of only Na₂CO₃-treated fibre was done. From the water extract of the treated fibre, pectin, hemicellulose and lignin were estimated. The presence of hemicellulose or lignin was not detected. Pectin was estimated from the fibre treated for different periods. Fig. 7 shows the removal of pectinous matter from the treated fibre with respect to untreated fibre. It is evident that the dissolution of pectinous matter gets saturated in 16-24 h. Therefore, for the best cleaning, 24 h of treatment with the weak alkali was considered.

3.3 Effect of Treatment on Fibre Tenacity

The fibre samples (both untreated and treated with 0.25% Na₂CO₃ for 24 h) were subjected for the measurement of fineness, strength and elongation at break. The results (Table 1) show that
Fig. 2—Scanning electron photomicrograph of raw jute fibres treated with (a) 0.25% $\text{Na}_2\text{CO}_3$ for 1h, (b) 0.25% $\text{Ca(OH)}_2$ for 10 min, (c) 0.25% liquor $\text{NH}_3$ for 10 min, and (d) 0.25% $\text{Na}_2\text{SO}_3$ for 10 min

Fig. 3—Scanning electron photomicrograph of raw jute fibres treated with (a) 0.25% $\text{Na}_2\text{CO}_3$ for 4h, and (b) 0.25% $\text{Ca(OH)}_2$ for 20 min.
there is no change in fineness. It is also evident that though there is some dissolution of non-cellulosic matter from the fibre surface (as revealed by SEM photographs), the fibre tenacity is not affect-
Table 2—Observed end breaks and properties of yarns spun from untreated and treated jute fibres

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mill-1</th>
<th>Mill-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Experimental</td>
</tr>
<tr>
<td></td>
<td>Set-1</td>
<td>Set-2</td>
</tr>
<tr>
<td>Quality ratio (yarn tenacity)</td>
<td>77.0</td>
<td>83.0</td>
</tr>
<tr>
<td>Strength CV%</td>
<td>19.8</td>
<td>18.2</td>
</tr>
<tr>
<td>Ends down/100 spindle-hour</td>
<td>149.0</td>
<td>101.0</td>
</tr>
<tr>
<td>Grist at 16% moisture regain, lb</td>
<td>7.8</td>
<td>8.5</td>
</tr>
<tr>
<td>Yarn moisture, %</td>
<td>13.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Irregularity, U%</td>
<td>21.0</td>
<td>21.5</td>
</tr>
</tbody>
</table>

Set-2 and Set-3 in Mill-1 and Set-2 in Mill-2 are the repeat experiments of Set-1. The machine parameters for Set-1 and normal were same except that chemicals were added in the emulsion for experimental.

3.4 Spinning Performance

Hessian warp yarn with nominal grist of 8 lb (276 tex) were spun in two member mills using 0.25% Na₂CO₃ (on the weight of the fibre) in jute batching oil emulsion. The spinning was carried out in the member mills by using more or less the same product mix. In each mill, one spinning frame with average mechanical condition was selected for study of end breakage rate. The observed spinning end breakage and yarn properties are given in Table 2. The results show that the quality ratio (yarn tenacity) of both untreated and treated yarns remains unchanged. However, there is a considerable decrease in the spinning end breaks/100 spindle-hour in the case of treated yarn in the both mills.

4 Conclusions

It was expected that the dilute alkali may dissolve some non-cellulosic matter giving rise to better fibre fineness which may lead to higher quality ratio of the yarn. But the above studies reveal that there is no change in fibre fineness or tenacity. However, the fibre surface is cleaned more without any damage because of the dissolution of pectinous matter by the dilute solution of sodium carbonate. The yarn spun from alkali-treated fibre does not show any improvement in quality ratio but considerable reduction in the spinning end breakage rate gives rise to higher production. There may be two possible reasons for this. Either the inter-fibre resistance is increased due to cleaning operation, leading to less yarn breakage, or the fibre itself becomes more regular due to treatment. The second one is more plausible because the diameter CV% of the treated fibre is much less (8-20%) than that of the untreated fibre (28-48%) and the more the fibre is regular the less is the yarn breakage.

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References


